# CLAIMS

1. A method for measuring frequency characteristics of a direct current acceleration sensor, comprising:

supporting a metal rod (1) with a center axis thereof aligned with a direction of gravity acceleration,

impacting one of end surfaces (2) of the metal rod with a projectile (3) to generate and propagate an elastic wave pulse in the metal rod,

using a direct current acceleration sensor (23) provided on the other of the end surfaces (22) of the metal rod to detect an acceleration arising when the elastic wave pulse reflects at the other end surface of the metal rod,

using a strain gauge (25) provided on a side surface of the metal rod to measure metal rod strain caused by the impact of the projectile against the other end surface of the metal rod, and

obtaining a frequency response of the direct current acceleration sensor from a signal from the direct current acceleration sensor and a signal from the strain gauge.

2. A method for measuring frequency characteristics of a direct current acceleration sensor, comprising:

supporting a metal rod (1) with a center axis thereof aligned with a direction of gravity acceleration,

impacting one of end surfaces (2) of the metal rod with a projectile (3) to generate and propagate an elastic wave pulse in the metal rod,

using a direct current acceleration sensor (23) provided on the other of the end surfaces (22) of the metal rod to detect an acceleration arising when the elastic wave pulse reflects at the other end surface of the metal rod,

using an optical measuring instrument (24) to measure a velocity of motion of the other end surface of the metal rod arising when the elastic wave pulse reflects at the other end surface of the metal rod, and

obtaining a frequency response of the direct current acceleration sensor from a signal from the direct current acceleration sensor and a signal from the optical measuring instrument.

3. A method for measuring frequency characteristics of a direct current acceleration sensor, comprising:

supporting a metal rod (1) with a center axis thereof inclined at a prescribed angle to a direction of gravity acceleration,

impacting one of end surfaces (2) of the metal rod with a projectile (3) to generate and propagate an elastic wave pulse in the metal rod,

using a direct current acceleration sensor (23) provided on the other of the end surfaces (22) of the metal rod to detect an acceleration arising when the elastic wave pulse reflects at the other end surface of the metal rod,

using a strain gauge (25) provided on a side surface of the metal rod to measure metal rod strain caused by the impact of the projectile against the other end surface of the metal rod, and

obtaining from a signal from the direct current acceleration sensor and a signal from the strain gauge a frequency response of the direct current acceleration sensor, with the direct current acceleration sensor affected by the gravity acceleration, and comparing data of said frequency response of the direct current acceleration sensor with data of the frequency response obtained by the method of claim 1, thereby obtaining characteristics with respect to the gravity acceleration in said frequency response of the direct current acceleration sensor.

4. A method for measuring frequency characteristics of a direct current acceleration sensor, comprising:

supporting a metal rod (1) with a center axis thereof inclined at a prescribed angle to a direction of gravity acceleration,

impacting one of end surfaces (2) of the metal rod with a projectile (3) to generate and propagate an elastic wave pulse in the metal rod,

using a direct current acceleration sensor (23) provided on the other of the end surfaces (22) of the metal rod to detect an acceleration arising when the elastic wave pulse reflects at the other end surface of the metal rod,

using an optical measuring instrument (24) to measure a velocity of motion of the other end surface of the metal rod arising when the elastic wave pulse reflects at the other end surface of the metal rod, and

obtaining from a signal from the direct current acceleration sensor and a signal from the optical measuring instrument a frequency response of the direct current acceleration sensor in a state in which the gravity acceleration affects the direct current acceleration sensor and comparing data of said frequency response of the direct current acceleration sensor with data of the frequency response obtained by the method of claim 2, thereby obtaining characteristics with respect to the gravity acceleration in said frequency response of the direct current acceleration sensor.

5. A method for measuring frequency characteristics of a direct current acceleration sensor, comprising:

supporting a metal rod (1) with a center axis thereof aligned with a direction of gravity acceleration,

releasing support of the metal rod to produce a free fall state,

during a period of releasing the support of the metal rod, impacting one of end surfaces (2) of the metal rod with a projectile (3) to generate and propagate an elastic wave pulse in the metal rod,

using a direct current acceleration sensor (23) provided on the other of the end surfaces (22) of the metal rod to detect an acceleration arising when the elastic wave pulse reflects at the other end surface of the metal rod,

using a strain gauge (25) provided on a side surface of the metal rod to measure metal rod strain caused by the impact of the projectile against the other end surface of the metal rod,

supporting the metal rod immediately after measuring the strain, and

obtaining a frequency response of the direct current acceleration sensor from a signal from the direct current acceleration sensor and a signal from the strain gauge.

6. A method for measuring frequency characteristics of a direct current acceleration sensor, comprising:

supporting a metal rod (1) with a center axis thereof aligned with a direction of gravity acceleration,

releasing support of the metal rod to produce a free fall state,

during a period of releasing the support of the metal rod, impacting one of end surfaces (2) of the metal rod with a projectile (3) to generate and propagate an elastic wave pulse in the metal rod,

using a direct current acceleration sensor (23) provided on the other of the end surfaces (22) of the metal rod to detect an acceleration arising when the elastic wave pulse reflects at the other end surface of the metal rod,

using an optical measuring instrument (24) to measure a velocity of motion of the other end surface of the metal rod arising when the elastic wave pulse reflects at the other end surface of the metal rod,

supporting the metal rod immediately after measuring the velocity of motion, and

obtaining a frequency response of the direct current acceleration sensor from a signal from the direct current acceleration sensor and a signal from the optical measuring instrument.

7. A method for measuring frequency characteristics of a direct current acceleration sensor according to any one of claims 1, 3 and 5, in which

the one end surface (2) of the metal rod (1) is impacted with the projectile (3) to generate the elastic wave pulse in the metal rod, further comprising:

taking as an input signal to the direct current acceleration sensor (23) provided on the other end surface (22) of the metal rod dynamic displacement, velocity or acceleration in a direction normal to the other end surface produced when the elastic wave pulse generated by the impact of the projectile reflects at the other end surface,

using the direct current acceleration sensor to detect, and the strain gauge (25) provided on the side surface of the metal rod to measure, the input signal having time as a function,

carrying out signal processing with respect to an output signal from the direct current acceleration sensor and an output signal from the strain gauge, and

using data that has been signal processed as a basis for measuring gain-frequency characteristics, phase-frequency characteristics and peak sensitivity of the direct current acceleration sensor in respect of each of dynamic displacement detection function, velocity detection function and acceleration detection function of the direct current acceleration sensor.

8. A method for measuring frequency characteristics of a direct current acceleration sensor according to any of claims 1, 3 and 5, in which the one end surface (2) of the metal rod (1) is impacted with the projectile (3) to generate the elastic wave pulse in the metal rod, further comprising:

taking as an input signal to the direct current acceleration sensor (23) provided on the other end surface (22) of the metal rod dynamic displacement, velocity or acceleration in a direction normal to the other end surface produced when the elastic wave pulse generated by the impact of the projectile reflects at the other end surface,

using the direct current acceleration sensor to detect, and the strain gauge (25) provided on the side surface of the metal rod to measure, the input

signal having time as a function,

carrying out signal processing of an output signal from the direct current acceleration sensor and an output signal from the strain gauge,

carrying out error correction of the output signal from the strain gauge based on elastic wave theory, and

using data that has been signal processed and error corrected as a basis for measuring gain-frequency characteristics, phase-frequency characteristics and peak sensitivity of the direct current acceleration sensor in respect of each of dynamic displacement detection function, velocity detection function and acceleration detection function of the direct current acceleration sensor.

9. A method for measuring frequency characteristics of a direct current acceleration sensor according to any one of claims 2, 4 and 6, in which the one end surface (2) of the metal rod (1) is impacted with the projectile (3) to generate the elastic wave pulse in the metal rod, further comprising:

taking as an input signal to the direct current acceleration sensor (23) provided on the other end surface (22) of the metal rod dynamic displacement, velocity or acceleration in a direction normal to the other end surface produced when the elastic wave pulse generated by the impact of the projectile reflects at the other end surface,

using the direct current acceleration sensor to detect, and the optical measuring instrument (24) to directly measure, the input signal having time as a function,

carrying out signal processing with respect to an output signal from the direct current acceleration sensor and the output signal from the optical measuring instrument, and

using data that has been signal processed as a basis for measuring gain-frequency characteristics, phase-frequency characteristics and peak sensitivity of the direct current acceleration sensor in respect of each of

dynamic displacement detection function, velocity detection function and acceleration detection function of the direct current acceleration sensor.

10. A method for measuring frequency characteristics of a direct current acceleration sensor according to any one of claims 1, 3 and 5, in which the one end surface (2) of the metal rod (1) is impacted with the projectile (3) to generate the elastic wave pulse in the metal rod, further comprising:

taking as an input signal to the direct current acceleration sensor (23) provided on the other end surface (22) of the metal rod dynamic displacement, velocity or acceleration in a direction normal the other end surface produced when the elastic wave pulse generated by the impact of the projectile reflects at the other end surface,

using the direct current acceleration sensor to detect, and the strain gauge (25) provided on the side surface of the metal rod to measure, the input signal having time as a function,

carrying out signal processing of an output signal from the direct current acceleration sensor and an output signal from the strain gauge,

carrying out error correction of the output signal from the strain gauge based on elastic wave theory,

using a correction function relating to dynamic characteristics of the strain gauge to correct results of measurements by the gauge, and

using data that has been signal processed, error corrected and measurement-result-corrected as a basis for measuring gain-frequency characteristics, phase-frequency characteristics and peak sensitivity of the direct current acceleration sensor in respect of each of dynamic displacement detection function, velocity detection function and acceleration detection function of the direct current acceleration sensor.

11. A method for measuring frequency characteristics of a direct current acceleration sensor according to any one of claims 7, 8 and 10, wherein the strain gauge provided on the side surface of the metal rod is composed of a plurality of strain gauges provided at different distances from the one end surface of the metal rod.

12. A method for measuring frequency characteristics of a direct current acceleration sensor according to any one of claims 7, 8, 10 and 11, wherein the strain gauge provided on the side surface of the metal rod is composed of a plurality of strain gauges provided on the circumference at equal distances from the one end surface of the metal rod.

13. A method for measuring frequency characteristics of a direct current acceleration sensor according to any of claims 7 to 12, wherein the projectile (3) that impacts the one end surface of the metal rod is composed of a plurality of round, concentric projectiles (8, 10, 12) launched from a launch apparatus (14) that includes multiple round, concentric launch tubes (4, 5, 6), in which the launch apparatus can precisely and independently control launch timing of each projectile launched.

14. An apparatus for measuring frequency characteristics of a direct current acceleration sensor, comprising:

a metal rod support apparatus (31) that supports a metal rod (1) with a center axis thereof aligned with a direction of gravity acceleration,

a launch apparatus (14) for impacting one of end surfaces (2) of a metal rod with a projectile (3) to generate an elastic wave pulse in the metal rod,

a direct current acceleration sensor (23) provided on the other of the end surfaces (22) of the metal rod to detect an acceleration arising when the elastic wave pulse reflects at the other end surface of the metal rod,

a strain gauge (25) provided on a side surface of the metal rod to measure metal rod strain caused by the impact of the projectile against the other end surface of the metal rod, and

a processor for calculating a frequency response of the direct current acceleration sensor from a signal from the direct current acceleration sensor and a signal from the strain gauge.

15. An apparatus for measuring frequency characteristics of a direct current acceleration sensor, comprising:

a metal rod support apparatus (31) that supports a metal rod (1) with a center axis thereof aligned with a direction of gravity acceleration,

a launch apparatus (14) for impacting one of end surfaces (2) of a metal rod with a projectile (3) to generate an elastic wave pulse in the metal rod,

a direct current acceleration sensor (23) provided on the other of the end surfaces (22) of the metal rod to detect an acceleration arising when the elastic wave pulse reflects at the other end surface of the metal rod,

an optical measuring instrument (24) for measuring a velocity of motion of the other end surface of the metal rod arising when the elastic wave pulse reflects at the other end surface of the metal rod, and

a processor for calculating a frequency response of the direct current acceleration sensor from a signal from the direct current acceleration sensor and a signal from the optical measuring instrument.

16. An apparatus for measuring frequency characteristics of a direct current acceleration sensor, comprising:

a metal rod support apparatus (31) that supports a metal rod (1) with a center axis thereof inclined at a prescribed angle to a direction of gravity acceleration,

a launch apparatus (14) for impacting one of end surfaces (2) of the metal rod with a projectile (3) to generate an elastic wave pulse in the metal

rod,

a direct current acceleration sensor (23) provided on the other of the end surfaces (22) of the metal rod to detect an acceleration arising when the elastic wave pulse reflects at the other end surface of the metal rod,

a strain gauge (25) provided on a side surface of the metal rod to measure metal rod strain caused by the impact of the projectile against the other end surface of the metal rod, and

a processor that obtains a frequency response of the direct current acceleration sensor, with the direct current acceleration sensor affected by the gravity acceleration, from a signal from the direct current acceleration sensor and a signal from the strain gauge and compares data of said frequency response of the direct current acceleration sensor with data of the frequency response calculated by the processor in claim 14 to calculate characteristics with respect to gravity acceleration in said frequency response of the direct current acceleration sensor.

17. An apparatus for measuring frequency characteristics of a direct current acceleration sensor, comprising:

a metal rod support apparatus (31) that supports a metal rod (1) with a center axis thereof inclined at a prescribed angle to a direction of gravity acceleration,

a launch apparatus (14) for impacting one of end surfaces (2) of the metal rod with a projectile (3) to generate an elastic wave pulse in the metal rod,

a direct current acceleration sensor (23) provided on the other of the end surfaces (22) of the metal rod to detect an acceleration arising when the elastic wave pulse reflects at the other end surface of the metal rod,

an optical measuring instrument (24) for measuring a velocity of motion of the other end surface of the metal rod arising when the elastic wave pulse reflects at the other end surface of the metal rod, and

a processor that obtains a frequency response of the direct current acceleration sensor, with the direct current acceleration sensor affected by the gravity acceleration, from a signal from the direct current acceleration sensor and a signal from the optical measuring instrument and compares data of said frequency response data with data of the frequency response of the direct current acceleration sensor calculated by the processor described in claim 15 to calculate characteristics with respect to gravity acceleration in said frequency response.

18. An apparatus for measuring frequency characteristics of a direct current acceleration sensor, comprising

a metal rod support apparatus (31) that supports a metal rod (1) with a center axis thereof aligned with a direction of gravity acceleration, releases support of the metal rod to produce a free fall state and re-supports it after a prescribed time,

a launch apparatus (14) that during a period of releasing the support of the metal rod impacts one of end surfaces (2) of the metal rod with a projectile (3) to generate an elastic wave pulse in the metal rod,

a direct current acceleration sensor (23) provided on the other of the end surfaces (22) of the metal rod to detect an acceleration arising when the elastic wave pulse reflects at the other end surface of the metal rod,

a strain gauge (25) provided on a side surface of the metal rod to measure metal rod strain caused by the impact of the projectile against the other end surface of the metal rod, and

a processor for calculating a frequency response of the direct current acceleration sensor from a signal from the direct current acceleration sensor and a signal from the strain gauge.

19. An apparatus for measuring frequency characteristics of a direct current acceleration sensor, comprising:

a metal rod support apparatus (31) that supports a metal rod (1) with a center axis thereof aligned with a direction of gravity acceleration, releases support of the metal rod to produce a free fall state and re-supports it after a prescribed time,

a launch apparatus (14) that during a period of releasing the support of the metal rod impacts one of end surfaces (2) of the metal rod with a projectile (3) to generate an elastic wave pulse in the metal rod,

a direct current acceleration sensor (23) provided on the other of the end surfaces (22) of the metal rod to detect an acceleration arising when the elastic wave pulse reflects at the other end surface of the metal rod during the period of releasing the support of the metal rod,

an optical measuring instrument (24) for measuring a velocity of motion of the other end surface of the metal rod arising when the elastic wave pulse reflects at the other end surface of the metal rod, and

a processor for calculating a frequency response of the direct current acceleration sensor from a signal from the direct current acceleration sensor and a signal from the optical measuring instrument.

20. An apparatus for measuring frequency characteristics of a direct current acceleration sensor according to any one of claims 14, 16 and 18, including the launch apparatus (14) for impacting the one end surface (2) of the metal rod with the projectile (3) to generate the elastic wave pulse in the metal rod, wherein the direct current acceleration sensor (23) detects an input signal having time as a function that is dynamic displacement, velocity or acceleration in a direction normal to the other end surface produced when the elastic wave pulse generated by the impact of the projectile reflects at the other end surface (22) of the metal rod, said input signal constituting an input signal to the direct current acceleration sensor (23) provided on the other end surface, the strain gauge (25) provided on the side surface of the metal rod measures metal rod strain caused by the impact of the projectile against the

other end surface of the metal rod, and the processor carries out signal processing with respect to an output signal from the direct current acceleration sensor and an output signal from the strain gauge and uses data that has been signal processed as a basis for measuring gain-frequency characteristics, phase-frequency characteristics and peak sensitivity of the direct current acceleration sensor in respect of each of dynamic displacement detection function, velocity detection function and acceleration detection function of the direct current acceleration sensor.

21. An apparatus for measuring frequency characteristics of a direct current acceleration sensor according to any of claims 14, 16 and 18, including the launch apparatus (14) for impacting the one end surface (2) of the metal rod with the projectile (3) to generate the elastic wave pulse in the metal rod, wherein the direct current acceleration sensor (23) detects an input signal as a function of time standing for dynamic displacement, velocity or acceleration in a direction normal to the other end surface produced when the elastic wave pulse generated by the impact of the projectile reflects at the other end surface (22) of the metal rod, said input signal constituting an input signal to the direct current acceleration sensor provided on the other end surface, the strain gauge (25) provided on the side surface of the metal rod measures metal rod strain caused by the collision of a projectile, and the processor carries out signal processing with respect to an output signal from the direct current acceleration sensor and an output signal from the strain gauge, carries out error correction of the output signal from the strain gauge based on elastic wave theory, and uses data that has been signal processed and error corrected as a basis for measuring gain-frequency characteristics, phase-frequency characteristics and peak sensitivity of the direct current acceleration sensor in respect of each of dynamic displacement detection function, velocity detection function and acceleration detection function of the direct current acceleration sensor.

22. An apparatus for measuring frequency characteristics of a direct current acceleration sensor according to any one of claims 15, 17 and 19, including the launch apparatus (14) for impacting the one end surface (2) of the metal rod with the projectile (3) to generate an elastic wave pulse in the metal rod, wherein the direct current acceleration sensor (23) detects an input signal as a function of time standing for dynamic displacement, velocity or acceleration in a direction normal to the other end surface produced when the elastic wave pulse generated by the impact of the projectile reflects at the other end surface (22) of the metal rod, said input signal constituting an input signal to the direct current acceleration sensor provided on the other end surface, the optical measuring instrument (24) directly detects the input signal, and the processor carries out signal processing with respect to an output signal from the direct current acceleration sensor and an output signal from the optical measuring instrument and uses data that has been signal processed as a basis for measuring gain-frequency characteristics, phase-frequency characteristics and peak sensitivity of the direct current acceleration sensor in respect of each of dynamic displacement detection function, velocity detection function and acceleration detection function of the direct current acceleration sensor.

23. An apparatus for measuring frequency characteristics of a direct current acceleration sensor according to any one of claims 14, 16 and 18, including the launch apparatus (14) for impacting the one end surface (2) of the metal rod with the projectile (3) to generate the elastic wave pulse in the metal rod, wherein the direct current acceleration sensor (23) detects an input signal as a function of time standing for dynamic displacement, velocity or acceleration in a direction normal to the other end surface produced when the elastic wave pulse generated by the impact of the projectile reflects at the other end surface (22) of the metal rod, said input signal constituting an input signal to the direct current acceleration sensor provided on the other end

surface, the strain gauge (25) provided on the side surface of the metal rod measures metal rod strain caused by the collision of a projectile, and the processor carries out signal processing with respect to an output signal from the direct current acceleration sensor and an output signal from the strain gauge, carries out error correction of the output signal from the strain gauge based on elastic wave theory, uses a correction function relating to motion characteristics of the strain gauge obtained using an optical measuring instrument to correct results of measurement by the strain gauge and uses data that has been signal processed, error corrected and measurement-result corrected as a basis for measuring gain-frequency characteristics, phase-frequency characteristics and peak sensitivity of the direct current acceleration sensor in respect of each of dynamic displacement detection function, velocity detection function and acceleration detection function of the direct current acceleration sensor.

24. An apparatus for measuring frequency characteristics of a direct current acceleration sensor according to any one of claims 20, 21 and 23, wherein the strain gauge provided on the side surface of the metal rod is composed of a plurality of strain gauges provided at different distances from the one end surface of the metal rod.

25. An apparatus for measuring frequency characteristics of a direct current acceleration sensor according to any one of claims 20, 21, 23 and 24, wherein the strain gauge provided on the side surface of the metal rod is composed of a plurality of strain gauges provided at equal distances from the one end surface of the metal rod.

26. An apparatus for measuring frequency characteristics of a direct current acceleration sensor according to any one of claims 14 to 25, wherein the projectile (3) that impacts the one end surface of the metal rod is

composed of a plurality of round, concentric projectiles (8, 10, 12) launched from the launch apparatus (14) that includes multiple round, concentric launch tubes (4, 5, 6), and the launch apparatus can precisely and independently control launch timing of each projectile launched.

27. An apparatus for measuring frequency characteristics of a direct current acceleration sensor according to any one of claims 14 to 26, wherein the launch tube in the launch apparatus that launches the projectile has a surface treated to reduce friction with the projectile.

28. An apparatus for measuring frequency characteristics of a direct current acceleration sensor according to any one of claims 14 to 27, wherein the apparatus for measuring the frequency characteristics of the direct current acceleration sensor measures frequency characteristics from shock acceleration in a low peak, narrow frequency band domain of the direct current acceleration sensor.

29. An apparatus for measuring frequency characteristics of a direct current acceleration sensor according to any of claims 15, 17, 19, 22 and 28, wherein the optical measuring instrument comprises a laser interferometer.

30. An apparatus for measuring frequency characteristics of a direct current acceleration sensor according to claim 26, wherein the one end surface of the metal rod contacts a metal ball and the launch apparatus that launches a plurality of projectiles in a concentric circle from the multiple launch tubes precisely controls launch timing with respect to said metal ball to generate an elastic wave pulse in the metal rod.

31. An apparatus for measuring frequency characteristics of a direct current acceleration sensor according to any one of claims 14 to 29 wherein

the projectile has a structure that is a lamination of different materials to control a frequency band of the elastic wave pulse generated in the metal rod by the impact of the projectile.

32. An apparatus for measuring frequency characteristics of a direct current acceleration sensor according to any of claims 14 to 29, wherein in accordance with a theoretical propagation of the elastic wave in the metal rod, when obtaining transient signal distortion of an elastic wave pulse from the strain gauge output signal incident on the one end surface, at least a primary term of a series-expanded Skalak's analytic solution is used.

33. An apparatus for measuring frequency characteristics of a direct current acceleration sensor according to any of claims 14 to 29, wherein in accordance with a theoretical propagation of the elastic wave in the metal rod, when obtaining transient signal distortion of an elastic wave pulse from the strain gauge output signal incident on the one end surface, up to a high-order term of a series-expanded Skalak's analytic solution is used.

34. An apparatus for measuring frequency characteristics of a direct current acceleration sensor according to any one of claims 14 to 29, wherein the direct current acceleration sensor has a peak sensitivity determined in accordance with an input acceleration waveform and frequency band produced by a plurality of projectiles launched from the launch apparatus with precisely controlled launch timing.